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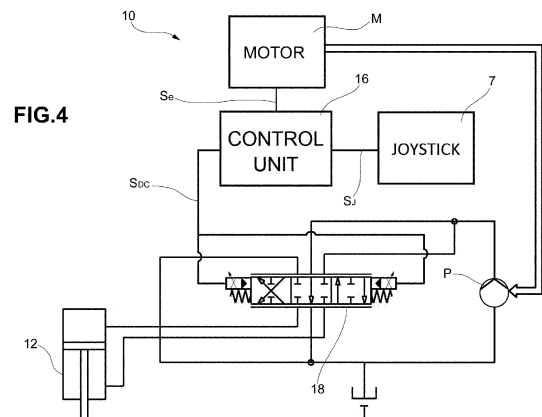
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(54) **A CONTROL METHOD FOR ACTUATING A SHAKE MOVEMENT OF A BUCKET CONNECTED TO A BOOM IN A WORK VEHICLE POWERED BY A MOTOR, A CORRESPONDING CONTROL SYSTEM AND A WORK VEHICLE COMPRISING SUCH CONTROL SYSTEM**

(57) A control method for actuating a shake movement of a bucket connected to a boom in a work vehicle powered by a motor is disclosed. Actuating the bucket occurs by means of a joystick controlled by a user, a movement of the joystick in a predetermined control area according to a preset axis causing the actuation of the bucket by an hydraulic actuator. The hydraulic actuator includes an open centre directional solenoid valve whose opening degree is controlled by means of a driving current as a function of the position of the joystick. The control method comprises acquiring a position of the joystick, acquiring a rotational speed of the motor, detecting the frequency of travel of the joystick from a first predetermined threshold position to a second predetermined threshold position reversed with respect to a neutral position, with a predetermined distance among them, and, if the frequency of travel of the joystick, is higher than a predetermined frequency threshold, supplying a predetermined shaking driving current evolving according to a square wave to the open centre directional solenoid valve, the predetermined shaking driving current being based on a reference model indicative of a nominal relation between the rotational speed of the motor and the amplitude of the driving current.



Description

Technical field

[0001] The present invention relates generally to a work vehicle, such as for example a compact wheel loader, and particularly to a control method of actuating a movement of a bucket connected to the boom in a work vehicle powered by a motor and to a corresponding control system.

Prior art

[0002] Motorized work vehicles are well known for use in material handling that carry a bucket and have a hydraulically operated lifting arm for moving the bucket. Examples of such vehicles are tractors and loaders.

[0003] A loader is a heavy equipment machine used in construction to move aside on the ground or load materials such as asphalt, demolition debris, dirt, snow, feed, gravel, logs, raw minerals, recycled material, rock, sand, woodchips, etc. into or onto another type of machinery (such as a dump truck, conveyor belt, feed-hopper, or railroad car). There are many types of loader, which, depending on design and application, are called by various names, including bucket loader, front loader, front-end loader, payloader, scoop, shovel, skip loader, wheel loader, or skid-steer. In particular, compact wheel loaders are compact vehicles that have road wheels and carry a working bucket, such as a bucket, attached to a lift arm or boom, that is hydraulically powered.

[0004] Referring to figure 1, a work vehicle 1, such as a compact wheel loader, is shown. However, the invention is not limited to such a kind of work vehicle, but is applicable to any other kind of work vehicle.

[0005] A compact wheel loader includes a bucket 2 connected to a frame 3 of the work vehicle for movement relative thereto. As shown, a pair of booms 5 (only one being shown) is each pivotally connected at one end on opposite sides of frame 3. The bucket 2 is pivotally connected at the opposite end of booms for tilting movement relative to the frame 3 about a generally horizontal axis. The above-described features form no substantial part of the present invention and are generally well known in the art. A bucket may be replaced in operation by any other bucket or attachment.

[0006] Usually, the movement of the bucket 2 is controlled by the user through a joystick 7 placed inside an operator's cab or cabin 9 of the work vehicle 1.

[0007] As can be seen in figure 2, which shows a control diagram of the work vehicle 1, the bucket 2 is moved by an hydraulic control circuit 10 comprising a hydraulic actuators 12 which is controlled by an electronic control unit 16 through a solenoid valves 18 according to the position of the joystick 7 controlled by the user.

[0008] Figure 3 shows an exemplary joystick of a work vehicle. A movement of the joystick 7 in a predetermined control area A according to a preset axis x causing the

actuation of the bucket by hydraulic actuating means. The preset axis x presents a neutral position N of the joystick.

[0009] The neutral position of the joystick is a position where the bucket is not actuated.

[0010] For example, according to the orientation depicted in figure 3, when the joystick is moved right from the neutral position N along the preset axis x, the bucket, is tilted towards a dumping position, and when the joystick is moved left from the neutral position N along the preset axis x, the bucket, is tilted towards a dig position and beyond.

[0011] Load-sensing valves allow a pressure compensation so that downstream channels take proportional allocation of flow depending on the load. The flow rate at a predetermined opening degree is not dependent upon the load downstream each valve and is not dependent upon the pump inlet flow.

[0012] When a plurality of loads is actuated, load-sensing valves with flow sharing also prevent the working fluid from taking the path of least resistance. However, this solution is very expensive. Advantageously, open centre directional solenoid valves are less expensive than load-sensing valves. Disadvantageously, in open centre directional solenoid valves the flow rate at a predetermined opening degree is dependent upon the pump inlet flow, the number of valves supplied by the pump and the load downstream each valve.

[0013] For example, the hydraulic actuator comprises an hydraulic cylinder operatively connected to the bucket, that uses hydraulic power of a working fluid to facilitate mechanical operation. The working fluid is controlled by means of an open centre directional solenoid valves 18. As liquids are nearly impossible to compress, a hydraulic actuator can exert a large force. The rate of actuation of the bucket is controlled by the opening degree of the open centre directional solenoid valve 18 by means of a driving current as a function of the position of the joystick 7.

[0014] The hydraulic flow rate of the working fluid required to operate the bucket is produced by a hydraulic fixed displacement pump P connected to a fluid reservoir T and driven by an internal combustion engine or an electrical motor M (hereinafter simply referred to as motor) of the vehicle, e.g. by a mechanical linkage. Therefore, the rate of movement of the bucket at a predetermined joystick position is dependent upon the motor rotational speed. For instance, when the motor is working at a high rotational speed, it is necessary a minimum movement of the joystick by the user to start the movement of the bucket. On the contrary, when the motor is working at a low rotational speed, it is necessary a large movement of the joystick by the user to start the movement of the bucket.

[0015] The situation is similar when the user try to stop the movement of the bucket through the joystick. For instance, when the motor is working at a high rotational speed, it is necessary to move the joystick at a first dis-

tance from the neutral position of the joystick to stop the actuation of the bucket. On the contrary, when the motor is working at a low rotational speed, it is necessary to move the joystick at a second distance from the neutral position of the joystick, higher than said first distance, to stop the actuation of the bucket.

[0016] In known work vehicle, there is a predetermined function provided to shake the bucket in order to remove undesired material form the bucket. Disadvantageously, this function is only allowed when the motor of the work vehicle is working at a high rotational speed since when the motor of the work vehicle is working at a low rotational speed the flow rate of the working liquid will be not sufficient to provide to the hydraulic actuator a sufficient force to perform the function to shake the bucket.

[0017] Disadvantageously, the controllability of the bucket by the user is affected since it will be possible to the user to clean the bucket through a shaking operation of the bucket only when the motor is working at high motor rotational speed.

Summary of the invention

[0018] The aim of the present invention is to provide a solution that avoids the drawbacks of the prior art. Particularly, an aim of the present invention is to improve the controllability of bucket in a work vehicle so as to allow the possibility to perform a function for shaking the bucket in order to remove undesired material form the bucket also when the motor of the work vehicle is working at low motor rotational speed.

[0019] According to the invention, this aim is achieved by a control method for actuating a movement of a bucket connected to a boom in a work vehicle powered by a motor, having the features claimed in claim 1.

[0020] Preferred embodiments are defined in the dependent claims, whose content is also to be considered an integral part of the present description. Features of the dependent claims may be combined with the features of the independent claims as appropriate, and in combinations other than those explicitly set out in the claims.

[0021] Further subjects of the invention are a control system for actuating a movement of a bucket connected to a boom in a work vehicle powered by a motor, as well as a work vehicle, as claimed.

[0022] In summary, an actuation strategy of a bucket (and possibly of any further attachment) of a work vehicle is disclosed. In said actuation strategy, according to the position of the joystick, it is recognized if a user is performing a shaking maneuverer and in such case, a proper driving current is provided to a open centre directional solenoid valve of the hydraulic actuating means that actuate the bucket, so as to allow a constant shake of the bucket in view of the motor rotational speed of the motor of the work vehicle.

Brief description of the drawings

[0023] Further functional and structural characteristics and advantages of the present invention are set out in the detailed description below, provided purely as a non-limiting example, with reference to the attached drawings, in which:

- figure 1 shows a prior art exemplary work vehicle, in particular a compact wheel loader;
- figure 2 shows a prior art control diagram of a work vehicle;
- figure 3 shows an exemplary joystick of a work vehicle; and
- figure 4 shows a control diagram of a work vehicle according to the invention.

Detailed description

[0024] In the following description, unless otherwise defined, all terms (including technical and scientific terms) are to be interpreted as is customary in the art. It will be further understood that terms in common usage should also be interpreted as is customary in the relevant art and not in an idealized or overly formal sense unless expressly so defined herein. All orientation terms, such as upper and lower, are used in relation to the drawings and should not be interpreted as limiting the invention.

[0025] In the following, a preferred embodiment of a control method for actuating a movement of a bucket connected to a boom in a work vehicle powered by a motor is described. Reference is made to the control diagram of Figure 2 that has been previously described, and the electronic control unit 16 is configured to bucket the control method of the invention.

[0026] As disclosed above and with further reference to Figure 3, actuation of the bucket 2 occurs by means of a joystick 7 controlled by a user, a movement of the joystick 7 in a predetermined control area A according to a preset axis x causes the actuation of the bucket 2 by hydraulic actuating means 12,

[0027] The hydraulic actuating means 12 include an hydraulic cylinder operatively connected the bucket 2, and an open centre directional solenoid valve 18 whose opening degree is adapted to control the flow of a working fluid to the hydraulic cylinder.

[0028] An hydraulic flow rate of the working fluid is produced by a hydraulic pump P driven by the motor M.

[0029] The rate of actuation of the bucket 2 is controlled by the opening degree of the open centre directional solenoid valve 18 by means of a driving current thereof as a function of a component of the position of the joystick 7 along said preset axis x in the control area A.

[0030] The control method comprises the steps of acquiring a signal or data indicative of a position of the joystick 7 along said preset axis x over time and of acquiring a signal or data indicative of a rotational speed of the motor M.

[0031] Further, the control method comprises the step of detecting the frequency of travel of the joystick 7 in said control area A from a first predetermined threshold position P1 to a second predetermined threshold position P2 arranged along said preset axis x and reversed with respect to a neutral position N, with a predetermined distance d among them.

[0032] In addition, if the frequency of travel of the joystick 7 in said control area A is higher than a predetermined frequency threshold, a predetermined shaking driving current evolving according to a square wave according to joystick movement along x axis, e.g. for a predetermined shaking time is provided to the open centre directional solenoid valve so as to produce a controlled shaking movement of the bucket. Said predetermined shaking time may, for example, be pre-set by the manufacturer or be dependent upon the number of joystick travels.

[0033] The predetermined shaking driving current is based on a predetermined reference model of the shaking driving current, indicative of a nominal relation between the rotational speed of the motor M, and the amplitude of the driving current to the open centre directional solenoid valve 18.

[0034] The predetermined reference model can be an analytical relationship between, or a map of numerical values in a bijective correspondence of the rotational speed of the motor M and the amplitude of the driving current to the open centre directional solenoid valve 18 in the form of inverse proportional relation.

[0035] Preferably, the first predetermined threshold position P1 is arranged along said preset axis x at a first distance d1 from the neutral position N according to a first oriented V1 direction and the second predetermined threshold position P2 is arranged along said preset axis x at a second distance d2 from the neutral position N according to a second oriented direction V2 opposite to the first oriented direction V1.

[0036] The square wave of the driving current can present an alternate passage of current value to Dumping solenoid or Rollback solenoid of the solenoid valve, those solenoids are responsible for bucket shake movement, in particular the square wave switches from a Dumping amplitude value of driving current to a Rollback amplitude value of driving current. Preferably, the Dumping amplitude value and the Rollback amplitude value can have the same amplitude value in absolute value.

[0037] The square wave of the driving current can have a frequency value comprised between two calibrated thresholds.

[0038] Preferably, the first predetermined threshold position P1 and the second predetermined threshold position P2 are preset by the manufacturer of the work vehicle 1.

[0039] Referring now to figure 4, the invention concerns also a control system 10 for actuating a movement of a bucket 2 connected to a boom 5 in a work vehicle 1 powered by a motor.

[0040] The control system 10 comprises first input means adapted to receive at least a signal S_j indicative of a position in a control area A of a joystick 7 controlled by a user for actuating the bucket 2, and second input means adapted to receive at least a signal S_e indicative of the rotational speed of a motor M powering the work vehicle 1.

[0041] Further, the control system 10 comprises storage means adapted to store a reference model of a shaking driving current, indicative of a nominal relation between the rotational speed of the motor, and the amplitude of the driving current to the open centre directional solenoid valve 18.

[0042] In addition, the control system 10 comprises output means adapted to issue at least a signal S_{DC} indicative of the shaking driving current intended to control an opening degree of the open centre directional solenoid valve 18 of hydraulic actuating means of said bucket 2.

[0043] The control system 10 is arranged to carry out a control method according to the invention.

[0044] The invention further concerns also a work vehicle 1, in particular compact wheel loader, comprising a motor for propulsion of the work vehicle, a bucket connected to a boom, a joystick 7 operatively controlled by a user for actuating the bucket 2 that is movable in a predetermined control area A according to a preset axis x for actuating the bucket 2.

[0045] Further, the work vehicle comprises hydraulic actuating means for actuating the bucket 2. The hydraulic actuating means include an hydraulic cylinder operatively connected respectively to the bucket 2, and an open centre directional solenoid valve 18 whose opening degree is adapted to control the flow of a working fluid to the hydraulic cylinder. The opening degree of said open centre directional solenoid valve 18 is operatively controlled by means of a driving current.

[0046] In addition, the work vehicle comprises a hydraulic pump driven by the motor of the work vehicle to produce the hydraulic flow rate of the working fluid and a control system for actuating the movement of the bucket 2 connected to a boom, according to the invention.

[0047] Therefore, by virtue of the present invention, it is possible for the user of the work vehicle to clean the bucket through a shaking operation of the bucket through a constant shake operation, independently from the fact that the motor of the work vehicle is working at low or high rotational speed.

[0048] The example embodiments are described in sufficient detail to enable those of ordinary skill in the art to bucket a control system in a work vehicle arranged to carry out the disclosed control method herein described.

[0049] Naturally, the principle of the invention remaining unchanged, the embodiments and the constructional details may vary widely from those described and illustrated purely by way of non-limiting example, without thereby departing from the scope of the invention as defined in the appended claims.

Claims

1. A control method for actuating a shake movement of a bucket connected to a boom in a work vehicle powered by a motor,
 - a) acquiring a signal or data indicative of the position of the joystick along said preset axis over time;
 - b) acquiring a signal or data indicative of a rotational speed of the motor;
 - c) detecting the frequency of travel of the joystick in said control area from a first predetermined threshold position to a second predetermined threshold position arranged along said preset axis and reversed with respect to a neutral position, with a predetermined distance among them;
 - d) if the frequency of travel of the joystick in said control area is higher than a predetermined frequency threshold, supplying a predetermined shaking driving current evolving according to a square wave to the open centre directional solenoid valve so as to produce a controlled shaking movement of the bucket, the predetermined shaking driving current being based on a predetermined reference model of the shaking driving current, indicative of a nominal relation between the rotational speed of the motor, and the amplitude of the driving current to the open centre directional solenoid valve.
2. A control method according to Claim 1, wherein the first predetermined threshold position is arranged along said preset axis at a first distance from the neutral position according to a first oriented direction and the second predetermined threshold position is arranged along said preset axis at a second distance from the neutral position according to a second oriented direction opposite to the first oriented direction.
3. A control method according to Claim 1 or 2, wherein
 - the square wave of the driving current presents an alternative passage of current value from a dumping amplitude value of driving current to a rollback amplitude value of driving current.
4. A control method according to Claim 3, wherein the dumping amplitude value and the rollback amplitude value has the same amplitude value in absolute value.
5. A control method according to any one of the preceding claims wherein the square wave of the driving current has a frequency value comprised between two calibrated thresholds.
6. A control method according to any one of the preceding claims, wherein the predetermined reference model is an analytical relationship between, or a map of numerical values in a bijective correspondence of the rotational speed of the motor and the amplitude of the driving current to the open centre directional solenoid valve in the form of an inverse proportional relation.
7. A control system for actuating a shake movement of a bucket connected to a boom in a work vehicle, comprising:
 - first input means adapted to receive at least a signal indicative of a position in a control area of a joystick controlled by a user for actuating the bucket;
 - second input means adapted to receive at least a signal indicative of the rotational speed of a motor powering the work vehicle;
 - storage means adapted to store a reference model of a shaking driving current, indicative of a nominal relation between the rotational speed of the motor, and the amplitude of the driving current to the open centre directional solenoid valve;
 - output means adapted to issue at least a signal indicative of the shaking driving current intended to control an opening degree of an open centre directional solenoid valve of hydraulic actuating means of said bucket, the system being arranged to carry out a control method according to any one of claims 1 to 6.
8. Work vehicle, in particular compact wheel loader, comprising
 - motor for propulsion of the work vehicle;
 - a bucket connected to a boom;
 - a joystick operatively controlled by a user for actuating the bucket, the joystick being movable in a predetermined control area according to a preset axis for actuating the bucket,

- hydraulic actuating means for actuating the bucket, wherein the hydraulic actuating means include an hydraulic cylinder operatively connected respectively to the bucket, and a open centre directional solenoid valve whose opening degree is adapted to control the flow of a working fluid to the hydraulic cylinder, the opening degree of said open centre directional solenoid valve being operatively controlled by means of a driving current; 5 10
- a hydraulic pump driven by the motor of the work vehicle to produce the hydraulic pressure of the working fluid;
- a control system for actuating the shake movement of the bucket connected to a boom, according to claim 7. 15

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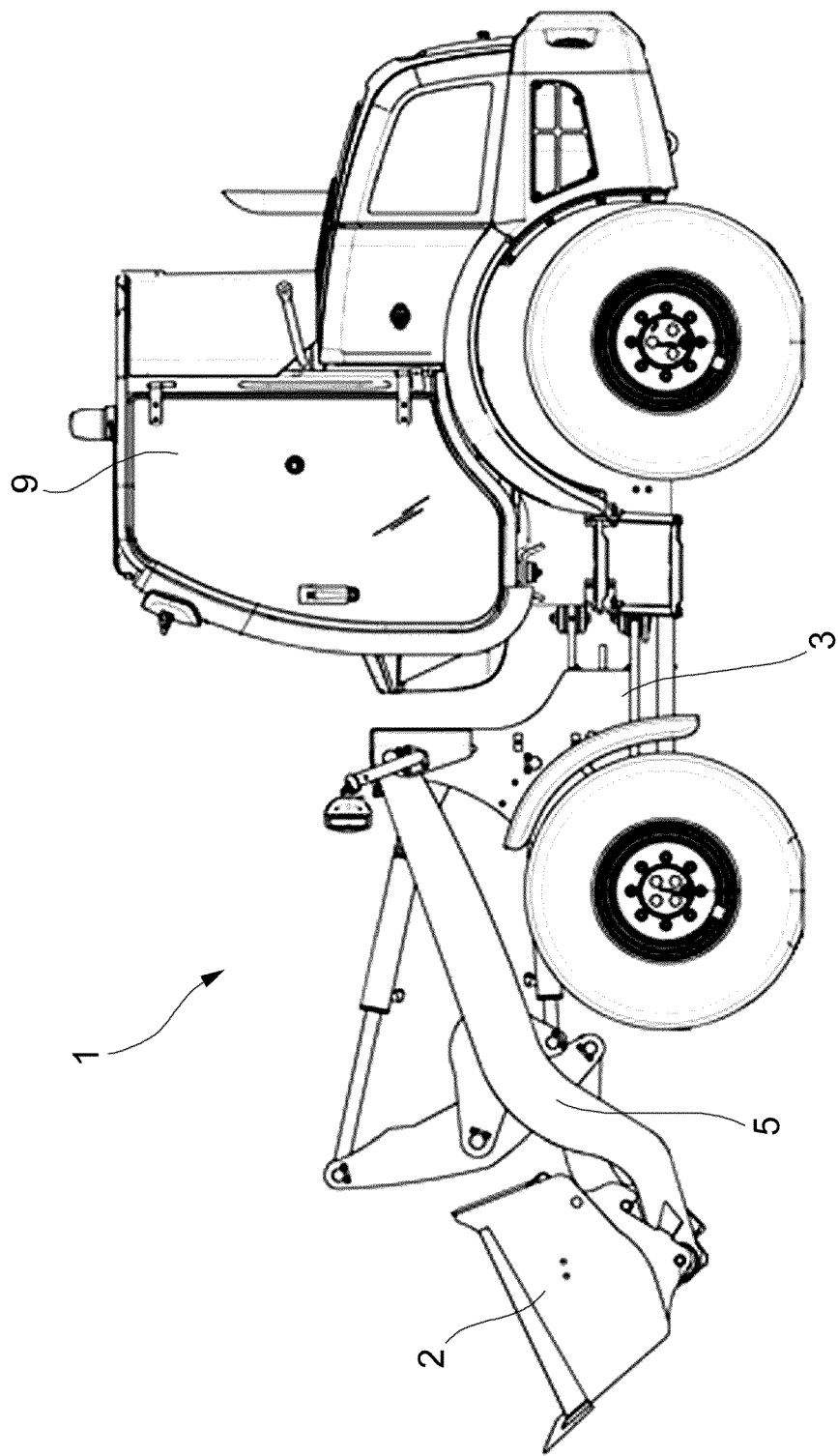
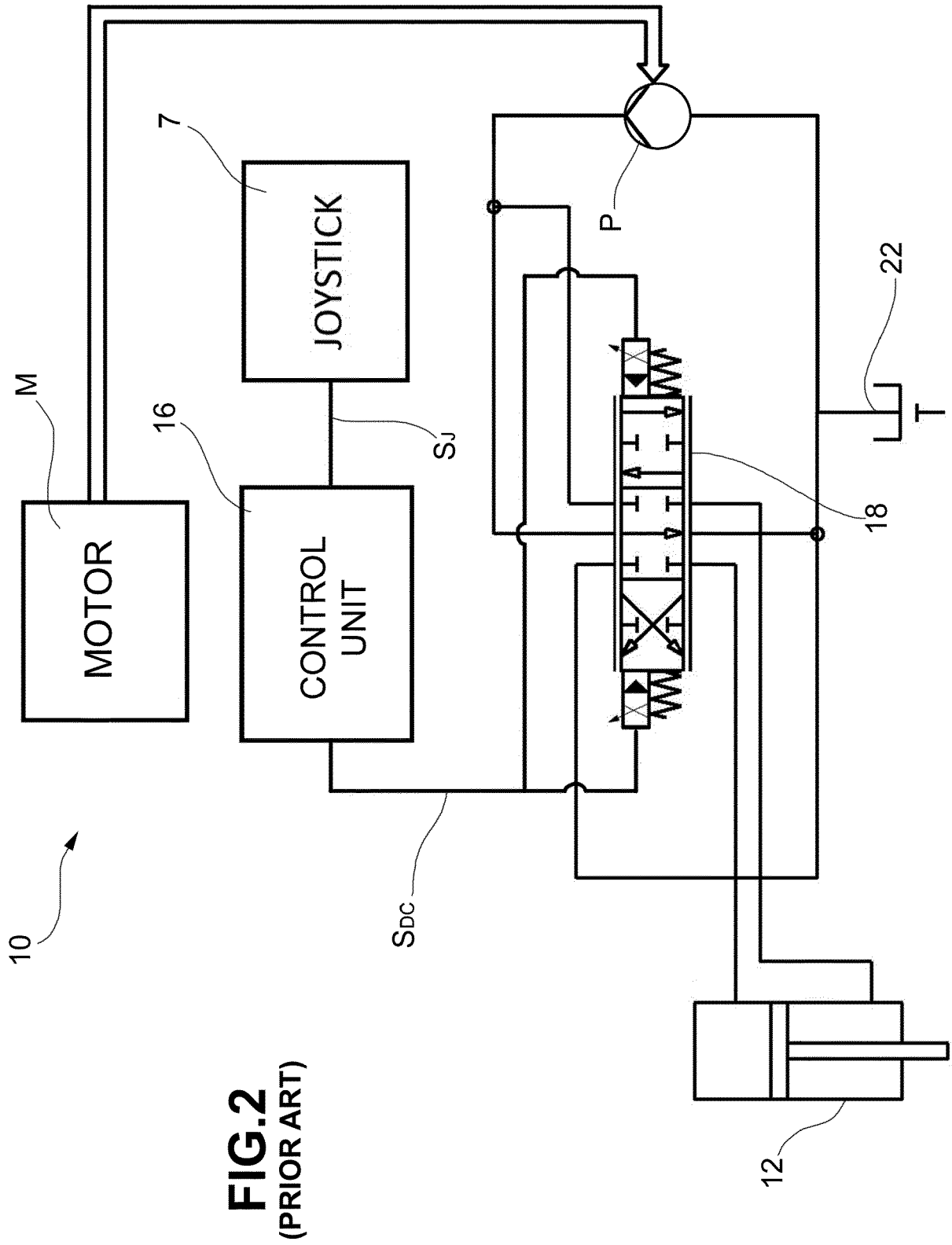


FIG.1
(PRIOR ART)



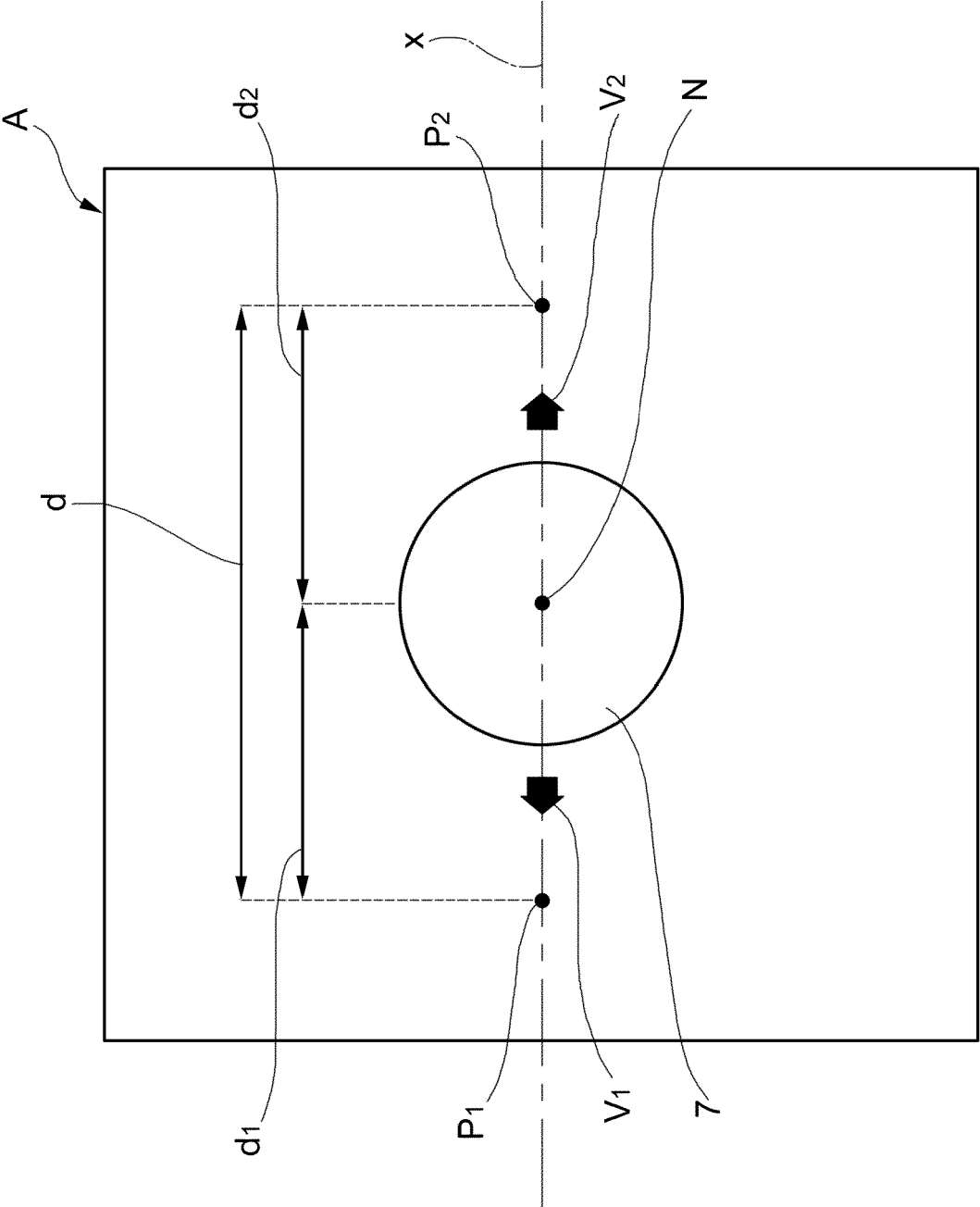
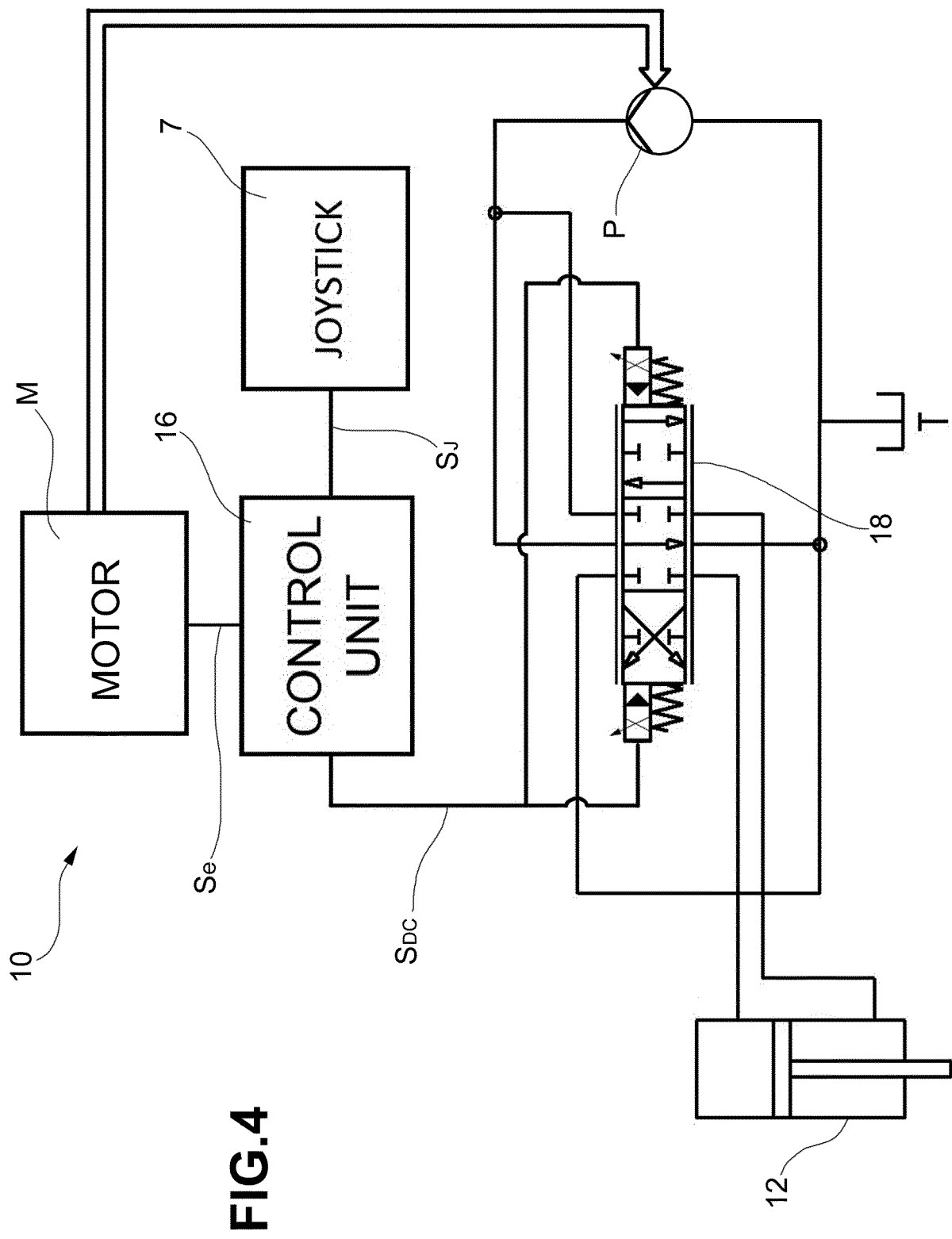


FIG.3





EUROPEAN SEARCH REPORT

Application Number
EP 20 16 8293

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2010/312437 A1 (SAITO YOSHIKI [JP]) 9 December 2010 (2010-12-09) * paragraph [0038]; figure 4 * * abstract; figures 1-3 *	1-8	INV. E02F9/20 E02F9/22 E02F3/43
A	EP 3 385 454 A1 (HITACHI CONSTRUCTION MACH CO [JP]) 10 October 2018 (2018-10-10) * abstract; figures 1-20 *	1-8	
A	US 5 493 798 A (ROCKE DAVID J [US] ET AL) 27 February 1996 (1996-02-27) * column 10, last paragraph - column 11, paragraph 1; figure 10 * * abstract *	1-8	
			TECHNICAL FIELDS SEARCHED (IPC)
			E02F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 29 May 2020	Examiner Ferrien, Yann
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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